FO OUTLOOK
NASA AMES RESEARCH CENTER

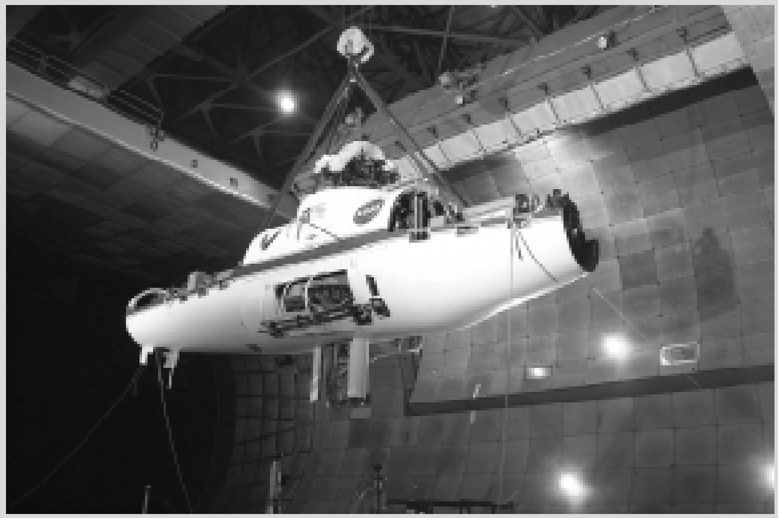
Information for the NASA Ames Wind Tunnel Test Community January 2003

First LRTA Test in 40-by-80-Foot Wind Tunnel

UH-60 TEST ON THE LARGE ROTOR TEST APPARATUS

By Don Nickison

This winter, the 40-by-80-Foot Wind Tunnel is again playing an important part in rotorcraft research as it tests the UH-60 Black Hawk rotor system on the Large Rotor Test Apparatus (LRTA). The test – part of a long-term NASA-Army rotorcraft research program – marks the first time that the LRTA has been installed in the 40-by-80-Foot Wind Tunnel.



LRTA being lifted into place in the 40-by-80-Foot Wind Tunnel

The purpose of the test, which started in January, is to verify operation of the UH-60's Individual Blade Control (IBC) system in forward flight at speeds up to 200 knots using a set of wide-chord rotor blades. The UH-60's rotor system with standard blades was tested previously on the LRTA at lower speeds in the 80-by-120-Foot Wind Tunnel. These tunnels have a long history of rotorcraft testing, including a test of the Tilt-Rotor Aeroacoustic Model (TRAM) in the 40-by-80-Foot Wind Tunnel in the fall of 2000.

Testing on the LRTA is a major undertaking for the Wind Tunnel Operations Division and provides valuable data to the rotorcraft research community. Data from the UH-60 test will help researchers better understand the performance of a new class of rotor blades and help develop flightworthy technologies, such as the IBC system, for reducing rotor noise and increasing performance.

The LRTA is a test bed having the shape of a generic rotorcraft. It was designed for testing different types of medium-to-large rotor systems. It exceeds the capability of the Rotor Test Apparatus (RTA), which has been used extensively for rotor testing at the National Full-Scale Aerodynamic Test Complex (NFAC) since the early 1970s. The RTA can test systems up to 45 feet in diameter with thrust loads up to 22,000 pounds while the LRTA can spin rotors up to 65 feet in diameter with thrust loads up to 50,000 pounds. The LRTA, designed and built under NASA-Army contract with Dynamic Engineering Inc., has two 3,000-horsepower electric motors that drive the rotor shaft using power from Ames' 150-hertz power supply system.

Previous LRTA tests were conducted in the 80-by-120-Foot Wind Tunnel from 2000 to 2002 to make sure that systems were ready for research testing and to test the load-sharing capabilities of the 150-hertz power system. Engineers also tested the UH-60 rotor system with the IBC and a Rotor Mounted Data Acquisition System (RMDAS) installed.

Facility Improvements

Despite the success of the 80-by120 test, gearing up for the LRTA entry into the smaller, higher-speed 40-by-80-Foot Wind Tunnel has been a challenge. At 35 tons when stripped down,

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INSIDE: Global Hawk Test • Code FO at SATA Conference • DOE Truck Test

F-16 Pod Test • Golf Tournament • Ames Honor and Spotlight Awards

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GLOBAL HAWK TEST IN THE 11-BY-11-FOOT TWT

By James M. Strong

A test of two-dimensional airfoils in the 11-by-11-Foot Transonic Wind Tunnel provided key data for wing selection on the Global Hawk unmanned surveillance aircraft. It also illustrated the ability of NASA Ames' divisions to coordinate their varied activities while meeting customer requirements under tight deadlines.

Global Hawk, made by Northrop Grumman Ryan Aeronautical Center, is capable of flying at altitudes above 60,000 feet while providing highly detailed images of large geographical areas. Prototypes of the Global Hawk, which can fly nonstop for 36 hours, have been used for surveillance in Afghanistan.

The Global Hawk unmanned surveillance aircraft. Photo from Air Force Link, http://www.af.mil

The test at Ames, conducted in late August and early September, provided an airfoil lift and performance database to help engineers compare flight Reynolds number data between the current airfoil design and a new one. Northrop Grumman and the Air Force are looking for a design that will allow Global Hawk to remain aloft even longer and with a greater payload.

The two-week test also sought to determine the source of differences seen between current 2-D airfoil data and flight tests as well as quantify manufacturing tolerance limits with regard to transition sensitivity.

The test separately studied two 2-D airfoils, each one a wing section having a 3-foot chord along its entire length. Each airfoil model spanned the full height of the test section, a setup that had not been done in the 11-by-11-Foot TWT for more than 20 years. Each model was mounted to the facility turntable and secured to a bearing assembly mounted in the tunnel ceiling.

Engineers obtained lift and pitching moment data from surface pressure taps as well as data integrated from a wake profile rake mounted behind the model. The test was unusual in that it ran at low pressures bordering the wind tunnel's operating envelope. This allowed replication of full-scale high altitude flight conditions for a portion of the wing.

The customer opted to have both the wind tunnel test and model construction done at Ames. The effort encompassed design and manufacture of the airfoils, drag rake, and mounting hard ware; facility modifications; pressure instrumentation; and data reduction. It involved Codes FE, FM, FMD, FMX, and AP as well as Code FO. With so many different tasks and organizations, careful planning and precise coordination were essential.

The test deadline also was a challenge. After the test was accepted, Ames had only two months to design, analyze, fabricate, assemble, and have everything ready to test. The center's shops worked around the clock for six weeks to produce the models and support hardware in time for the test. In addition, the models had to be built to a linear tolerance of within .005 inch. By comparison, a standard sheet of notebook paper is .003 inch thick.

Northrop Grumman Ryan Aeronautical Center obtained the data it needed for the possible wind redesign, and the company and Air Force gave Ames high marks for the test.

F-16 POD TEST IN THE 11-BY-11-FOOT TRANSONIC WIND TUNNEL

By Doug Atler

A recently completed test in the 11-by-11-Foot Transonic Wind Tunnel has assisted in important design decisions regarding geometric configurations of the Integrated Forward-Looking Infrared Targeting System (IFTS) installed on the F-16 Fighting Falcon.

Code FO tested a one-ninth scale model of the F-16 and several IFTS pod configurations over two weeks in mid-December. The IFTS pod mounts below the fuselage on the left side of the aircraft's inlet cowl.

Northrop Grumman Electronic Systems Division was the principal investigator for this test and Northrop Grumman's Air Combat Division provided the IFTS models.

Test coordination was shared among personnel from Northrop Grumman and Lockheed Martin's Aeronautics Company, which manufactures the F-16 aircraft. Lockheed Martin provided the aircraft model in a Block 60 configuration. This configuration is being sold to the United Arab Emirates.

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UH-60 TEST ON THE LRTA IN THE 40-BY-80

(Continued from page 1)

the LRTA was slightly over the rated capacity of the 40-by-80-Foot Wind Tunnel's bridge crane. Also, at 40 feet long, the LRTA had only a few feet of clearance when it was lifted into the test section in October.

In addition, the aerodynamic loads of the LRTA exceeded the capacity of the drag force balance and original facility model support systems. Fortunately, through the efforts of many key engineers and technicians from Codes FOO, FEE, FEF, and ARA, a method for safely lifting and supporting the model was designed and built last summer. *(See related story on page 8)*

Other smaller, but equally important, facility improvements also were made to upgrade the tail strut, hydraulics, and 150-hertz model drive power in the 40-by-80-foot test section. The tail strut has three telescoping sections that allow the model nose to be pitched up or down through an alpha angle of +/- 15 degrees. Several bearing parts were modified to ensure that the tail strut could handle the combination of model weight, rotor thrust, and aerodynamic loads from the tunnel without getting stuck in one position. New electric cables from the 150-hertz power system were installed and tested in the 40-by-80-Foot Wind Tunnel. Controls also were added so that the LRTA could be powered through a load-sharing configuration using two motor-generator sets located at the NFAC and the 14-Foot Wind Tunnel.

Finally, a hydraulic cart and new high-pressure piping rated to over 3,000 pounds per square inch were added to meet the model needs for the IBC system and other systems that rely on hydraulic pressure. These projects were work intensive and, in the case of the 150-hertz power system, represent the final phase of a multiyear project to enable NFAC to do high-power rotor tests.

In addition to the significant effort to make the facility ready, Code FOI is providing data systems that are equally important to the success of this test. Rotorcraft tests differ from fixed-wing tests primarily in the area of data collection speed. The NFAC Parametric Real-time Information Management Enterprise (NPRIME) will be the system used to collect, warehouse and share virtually all of the data. Nearly 200 channels of data will be collected, including acoustic data, at speeds of 2,048 samples per blade revolution – which works out to over 8,800 samples per second. FOI also will provide support for both the Monitor Front End Data System (MFEDS), which handles safety of flight information for the rotor control system, and the LRTA's RMDAS. Codes FOI and ARA, the Aeromechanics Branch of the Army/NASA Rotorcraft Division, will jointly provide support for the instrumentation and computing systems.

Test Goals

The UH-60 test in the 40-by-80-Foot Wind Tunnel seeks to determine the performance of a new wider-chord set of rotor blades and as well as to continue testing of the IBC System. The new rotor blades to be tested are approximately15 to 20 percent wider than the standard UH-60 blades previously tested with the LRTA.

The UH-60 Black Hawk helicopter.
Photo from Army Link, http://www.dtic.mil/armylink/

The new test also will focus on the IBC System, a newer technology in rotorcraft that can reduce noise. Conventional rotorcraft have fixed links between the swashplate – which is used to control the rotor – and the rotor blade. These links adjust the pitch or angle of attack of the rotor blades with respect to the plane of rotation. In contrast, IBC uses hydraulically adjustable links that allow each blade pitch angle to be individually modified.

This modification capability reduces the effect of rotor-induced vortices, a major cause of rotorcraft noise. On a conventional rotorcraft, the advancing blade creates a wake that the next blade hits, resulting in the loud "thump-thump-thump" associated with rotorcraft. But an IBC System significantly reduces noise because it can adjust the pitch of the following blade to miss the wake. Engineers will use data gathered during the test to study and further develop this technology.

With the LRTA now available for either of the NFAC's two large-scale wind tunnels, Ames Research Center offers a new research capability unique to rotorcraft testing. As part of NASA's Civil Transportation Initiative, the UH-60 test and other elements of the rotorcraft program will someday help alleviate air and ground transportation congestion by creating a vertical takeoff and landing aircraft quiet enough to operate in densely populated areas.

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TRUCK TEST IN THE 12-FOOT PRESSURE WIND TUNNEL

By Catalina Ortiz

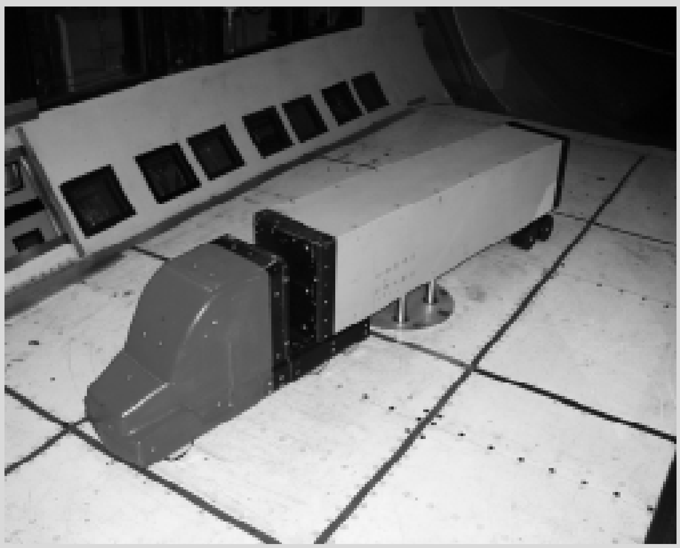
NASA Ames is playing an important part in a Department of Energy program to improve the aerodynamics of large trucks, which could save the U.S. trucking industry billions of gallons of diesel fuel a year.

In November, Code FO began testing a model of a heavy truck in the 12-Foot Pressure Wind Tunnel. The test is part of a DOE program that seeks to calibrate computational fluid dynamics (CFD) codes used in designing and modifying large trucks.

CFD codes, which create computer simulations of aerodynamic flows, don't predict vehicle drag very well. So when the industry designs and manufactures trucks, it still must go through a lot of costly and time-consuming trial and error.

"But if they have better CFD codes, they could do a better job and a cheaper job of designing new trucks," says Dale Satran, an Ames Code APS engineer. Code APS, a participant in the DOE program, is sponsoring the test on behalf of the agency. APS sponsored two previous truck tests for the DOE program in the 7-by-10-Foot Wind Tunnel.

The November entry was the first phase of the test in the 12-Foot Pressure Wind Tunnel. The second phase is expected to occur in early 2003.



Generic Conventional Model
in the 12-Foot Pressure Wind Tunnel

The Heavy Truck Model

Both phases test a generic conventional model (GCM) of a Class 8 heavy truck. The 12.5-percent-scale model, 8 feet long and 300 pounds, has the simplified shape of the common type of tractor-trailer with the driver's cab sitting behind the engine.

The tractor-trailer model is placed on the wind tunnel's semispan mounting system. An internal balance measures model forces and moments. In addition, two internal load cells measure drag loads just on the tractor portion of the model.

The test measures about 500 steady pressures, 12 unsteady pressures, and off-body velocities. The test runs at Mach numbers between .1 and .27 and a range of Reynolds numbers.

The GCM was tested in the 7-by-10-foot Wind Tunnel in early 2001 under the same DOE program. That test obtained an initial set of data for the DOE and industry and identified areas for future study.

Moving the model to the 12-Foot Pressure Wind Tunnel required some hardware changes because the two facilities use different mounting systems. In addition, because the 12-Foot Pressure Wind Tunnel operates at higher dynamic pressures than the 7-by-10-Foot Wind Tunnel, the model's load cells and flexure system needed to be resized.

Ames also used the 7-by-10-Foot Wind Tunnel to test another simplified truck model, the Ground Transportation System (GTS). The GTS, which looks like a stick of butter with one of the its short edges rounded over, has the shape of a tractor-trailer with the driver's cab directly over the engine. Unlike the GCM, the GTS model does not duplicate the gap between the tractor and trailer.

This gap is a source of increased drag on account of the vortices that form in it. During the second phase of the GCM test, engineers plan to use three-dimensional particle image velocimetry (PIV) to study the gap vortices. PIV – developed at Ames – is an imaging system that uses laser beams to measure the velocity and direction of airflow in a series of planes.

The DOE Program

The DOE program focuses on the largest trucks, which weigh up to 80,000 pounds each. According to the American Trucking Associations, an industry trade group, 2.6 million tractor-trailers haul 7.7 billion tons of freight year, 65 percent of all domestic freight.

The bluff, brick-like shape of large trucks generates considerable drag. For a typical large truck traveling at 70 mph, overcoming aerodynamic drag accounts for about 65 percent of the vehicle's total energy expenditure, according to DOE program researchers. So reducing drag can mean significant fuel savings.

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SATA CONFERENCE: THE WIND TUNNELS DOWN UNDER

Pete Zell and Phil Stich attended the annual Subsonic Aerodynamic Testing Association (SATA) conference in Melbourne, Australia. SATA members represent the operating organizations of a wide variety of low-speed wind tunnels from around the world. There is a similar organization for high-speed wind tunnels called the Supersonic Testing Association International (STAI).

The 2002 SATA meeting was co-hosted in August by Monash University and the Royal Melbourne Institute of Technology. These schools offer engineering degrees, and each one operates unique wind tunnels that support Australian research and development efforts. These facilities focus on vehicle aerodynamics and acoustics for two local car companies (Ford, GM), and on local wind engineering projects (buildings, smoke plumes, bridges).

Pete Zell and Phil Stich at a stop along the Great Ocean Road in southeast Australia

The SATA group also toured the facilities at the Defense Science & Technology Organization (DSTO), which include a continuous-flow transonic wind tunnel in the 4-foot-by-4-foot size range with a top speed of Mach 1.3. DSTO efforts focus on military aircraft upgrades for imported systems (such as the F-18). They also support Navy projects on ship hydrodynamics and aerodynamic wake effects on helicopters.

The presentations made during the conference ranged from honest discussions about failures experienced at several facilities to the latest test techniques being developed. Of particular interest to NASA Ames were:

- the development of a very-low-speed pressure sensitive paint process that is available as a service,
- a low-cost, puck-shaped, 6-component balance that is now available,
- consolidation of the European wind tunnel facilities under a single management,
- and the status of the 5-meter tunnel in Britain (a 12’ PWT competitor).

There were also many presentations on advances in automobile testing, including: new moving-belt floor systems, accurate modeling of road turbulence, and new test techniques. The car testing facilities have rapidly reached, and in some cases surpassed, the complexity of the aircraft test facilities. The SATA organization also welcomed new members from Malaysia, Indonesia, and Australia.

Pete and Phil experienced some of the local attractions in the Melbourne area. They attended two Australian Football League (www.afl.com.au). games. This exciting sport (“Footy” in Australia speak) is played by 16 teams representing Aussie cities and involves kicking a rugby-type ball through a set of goal posts They also drove the Great Ocean Road between Melbourne and Port Campbell (similar to our Highway 1). This was exciting since Australians drive on the left. Their motto was stay on the left (SOL) to avoid being SOL.

It also took a while to get used to the fact that August is wintertime in Australia and that the time difference is nearly a full day ahead (17 hours). The landscape was familiar, much like California north of San Francisco, but the local animals they saw definitely were not (kangaroos, wallabies, emus, wombats, etc). Phil and Pete report that Australians are generally very friendly with upbeat and optimistic attitudes. This is reflected in their favorite saying: “No worries, mate. She’ll be right.”

TRUCK TEST IN THE 12-FOOT PWT

(Continued from page 4)

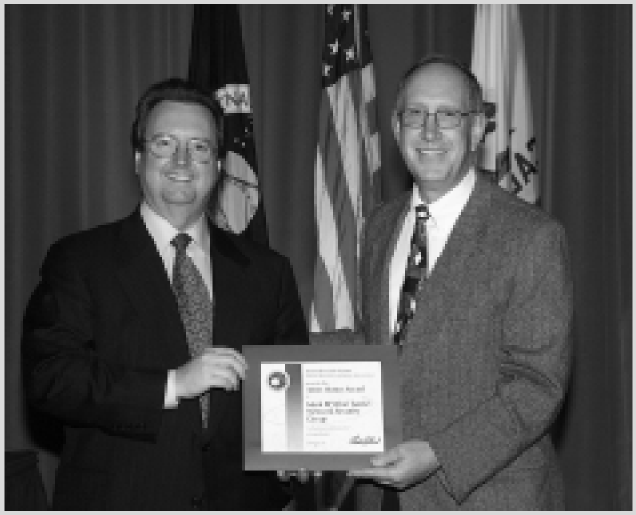
“It is conceivable the present-day truck drag coefficients might be reduced by as much as 50 percent,” according to a paper presented by DOE program researchers in 2000.

Truck manufacturers have been designing tractors with more streamlined shapes and adding fairings to improve the aerodynamics of existing ones. These include the curved, shield-like structures commonly seen atop tractor cabs and plates that narrow the gap between the tractor and trailer. Code APS hopes to evaluate some drag-reduction concepts during the second phase of the GCM test.

In addition to NASA, Lawrence Livermore National Laboratory, Sandia National Laboratories, Argonne National Laboratory, Georgia Tech Research Institute, the University of Southern California, and the California Institute of Technology are taking part in the DOE program.

FOI TEAM WINS HONOR AWARD FOR CUSTOM FIREWALL

A recent classified wind tunnel test posed an interesting network security challenge for Code FOI. The systems branch's response, quickly devising a way to protect sensitive customer information, has been recognized with an Ames Honor Award in the group or team category.



Ames Research Center Director G. Scott Hubbard presents an Ames 2002 Honor Award to FOI Chief Herb Finger. Finger and five other members of Code FOI were recognized in the group/ team category.

Six members of FOI – Jon Bader, Tom Bridge, Herb Finger, Gary Sorlien, Tom Volden, and Mark Zelinsky – were recognized for their roles in installing a customized firewall for the Mark III test held in the 11-by-11-Foot Transonic Wind Tunnel in May.

The test required a communications link to coordinate the activities of the customer's computers and Code FO's systems. However, the customer wanted to make sure that sensitive data on its computers would not inadvertently be distributed through the connection to Code FO's computers. The solution was a custom firewall, which would allow through only a few types of messages specific to the test.

The FOI team had only about a month to get the firewall in place, but not just any firewall would do. While firewalls usually filter messages based on their routing information, the test demanded a firewall that also could filter messages based on their content.

No off-the-shelf firewalls met FOI's requirements. However, Tom Volden found a commercial firewall that could be customized and a network security consultant who could do the customization in time for the classified test.

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SVERDRUP/ATOM SCRAMBLE GOLF TOURNEY

By Tom Bridge

Twenty-four players from the FO and AS divisions making up six teams took part in the fourth annual Sverdrup Scramble golf tournament at Santa Clara Golf and Tennis Club.

Jerry Mulenburg lifts the flag from the hole as Mike George prepares to putt

The tournament, held Sept. 19, started with lunch at the course followed by a quick warm-up, and the first group teed off at 11:30. The sun was high in the sky, and there was only a slight breeze on what is sometimes a windy course. Conditions were perfect for scoring so it is a mystery why no team did.

With a birdie barrage (two) on the final two holes, the team of Rich Exberger, Mike George, Jerry Mulenburg, and Phil Stich nosed out the team of Tom Bridge, Ed Heim, Phil Kopfinger, and "Doc" Theroux for first place. Every participating team was awarded some type of prize.

In the individual games, the long drives were belted by Ben Reduta and Phil Stich. The closest to the pin holes were won by Ed Heim, Frank Custer, Tom Bridge, and Jerry Mulenburg. Gary Sorlien was tournament director.

As per usual, the 19th hole was the one most closely contested and it was declared a draw between all six teams. Another successful tournament is now in the books and the reports from the players are that everyone had a great time. See you next year!

NASA AMES SPOTLIGHT AWARDS

Jim Kennon,Chad Brivkalns, and Frank L. Larsen – Global Hawk Test

Design engineers Jim Kennon and Chad Brivkalns and engineering technician Frank Larsen received Spotlight Awards for their contributions to the Global Hawk 2-D wing test last month in the 11-by-11-Foot Transonic Wind Tunnel. *(See related story on page 2)*

Jim Kennon, left, and Chad Brivkalns

Chad and Jim, with Code FEE, were responsible for designing all hardware, developing the computer models and providing structural analysis and conformance to wind tunnel operating criteria. Chad developed the detailed 3-D solid model of the test articles, two vertically mounted, 11-by-3-foot chord-length airfoil sections. Jim was responsible for the mounting structures, including a new ceiling-mounted turntable that supported the upper section of the model while allowing it to pivot. Jim also designed the model's flap-actuation system.

Frank, with Code FM, was in charge of project management of the fabrication of the Global Hawk model and all associated support hardware. He used his knowledge of materials and manufacturing to facilitate between the design engineers and all the model-building shops. Frank, within a short period of time, also coordinated the purchase of hardware and components.

Frank Larsen

The Global Hawk, made by Northrop Grumman Ryan Aeronautical Center, is an unmanned surveillance aircraft capable of flying above 60,000 feet for many hours while provide highly sophisticated surveillance. The test in the 11-by-11-Foot TWT provided performance data on the current airfoil as well as for a new wing design proposal.

All three say the relatively short period of time they had to design and build the model was the project's greatest challenge. Ames shop crews worked 24 hours a day for six days a week to meet the schedule. In addition, the shops had to produce two wing sections built to a linear tolerance of within .005 inch. By comparison, a standard sheet of notebook paper is .003 inch thick.

Frank says the project also was an example of how well Ames personnel – from designers to shop employees – work as a team. "I can't boost the people I work with enough because they continuously do what hasn't been done before," he says.

F-16 POD TEST IN THE 11-BY-11-FOOT TWT

(Continued from page 2)

The test comprised two phases, a dynamic pressure phase and a loads phase. The dynamic pressure phase obtained unsteady pressure data from two pod/pylon configurations, baseline and new, and from the inlet cowl at various pod nose orientation angles and inlet airflows.

The loads phase obtained aerodynamic force and moment data on the pod models utilizing a 0.5-inch, six-component balance that was installed inside the pod models. Various pod/pylon configurations, nose orientations, and inlet airflows were tested during the loads phase.

The test was conducted at Mach numbers ranging from 0.6 to 1.4 at a Reynolds number of 2.5 x10^6/ft. Angle of attack varied from -2° to $+28^\circ$ and angle of sideslip varied from -12° to $+12^\circ$. Pod nose orientations were rotated in 45° increments, and two inlet airflow ratios were set, 0.45 and 0.77.

In addition to the 0.5-inch balance, a 2.5-inch diameter task balance was utilized to monitor overall aircraft forces and moments. This was done to maintain safe conditions in the tunnel throughout test operations.

NASA AMES SPOTLIGHT AWARDS

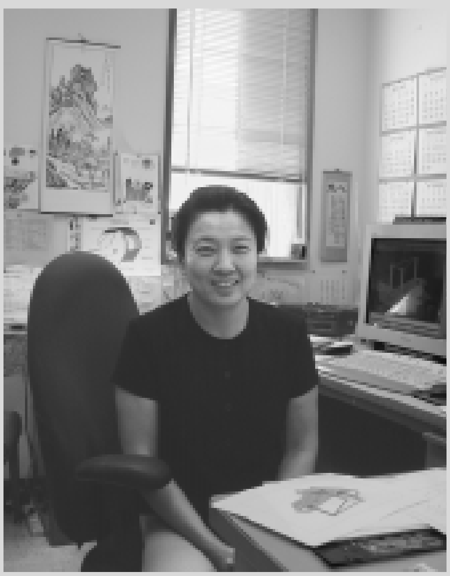
Jeff Blair, David Brown, and Xin Xin Nee – 40-by-80-Foot WT Model Support System

Jeff Blair, Xin Xin Nee, and Dave Brown have been recognized for their work in connection with the 40-by-80-foot Wind Tunnel's model support system for the Large Rotor Test Apparatus (LRTA).

Jeff Blair

Test engineers preparing for the UH-60 helicopter rotor test *(see related story on page 2)* were concerned with the model support system's capability to support the LRTA with its significantly high model weight and operational loads. The LRTA weighs 70,000 pounds and had not been previously tested in the 40-by-80-Foot Wind Tunnel. FOO facility engineers sought the assistance of various Ames Research Center engineers for design and analysis expertise.

Jeff Blair, a mechanical design engineer with Code FEE, focused on the model support system's rotating T-frame, which sits just below the test-section floor and supports the vertical struts, which in turn support the LRTA model. Jeff had to quickly relearn the complex finite-element program that was used to create and analyze the T-frame model. Using the anticipated load cases supplied by the test engineers, he was able to determine the maximum stresses in the T-frame structure. Jeff's analysis determined that the T-frame was capable of supporting the test loads.



Xin Xin Nee

Dave Brown, now an airworthiness engineer with Code JO, analyzed the intricate scale system below the balance house floor. Dave, a former FOF facility mechanical engineer, has spent a total of 15 years at NFAC. He computer modeled and analyzed the main lift lever of the scale system and determined that the LRTA would exceed the capacity of the lift lever. He then recommended that an alternate load path be used.

Xin Xin Nee, a structural engineer with Code FEF, analyzed and designed an alternate load path for the vertical loads. She constructed a detailed computer model of the floating frame, which supports the T-frame, and analyzed it under the maximum wheel loads from Jeff's analysis. Xin Xin also modeled the balance house structure and determined that it was capable of serving as the alternate load path to support the LRTA. Xin Xin also designed the structural modifications required to the floating frame and the balance house walls.

The work on the support system illustrates the biggest challenge facing FO in these changing times. More often we need to look to the broader resource base at Ames Research Center for technical support. It also exemplifies the teamwork and professionalism that exists within the larger Ames Research Center community when a schedule-critical project such as this is in need.

FOI TEAM WINS HONOR AWARD FOR FIREWALL

(Continued from page 6)

Tom Bridge worked with the customer to analyze traffic between the customer's computers and the wind tunnel's systems, and Jon Bader found a way to simplify the messages that would be allowed through the firewall.

Gary Sorlien worked to set up DARWIN services to support customer computers used for online data analysis and described the relationships between the wind tunnel network, NASA's DARWIN network, and the customer's computers so that the firewall wouldn't interfere with DARWIN services. Mark Zelinsky set up the hardware to test the firewall before the actual wind tunnel test could be run.

FOI Chief Herb Finger presided over the project and obtained the necessary approvals from NASA and the customer.

The firewall was tested, refined, and then used in the classified test. It worked as planned, allowing the customer to get the test data it needed while ensuring that sensitive information remained where it should.